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METHOD AND DEVICE FOR CARRYING OUT A BRAKING PROCESS

[0001] The invention relates to a method and a device for carrying out a braking process, a deceleration variable which describes the desired vehicle deceleration being reduced when the state of the vehicle during the braking process meets a first state condition, and the deceleration variable being increased again when the state of the vehicle meets a second state condition.

[0002] The method and the device are used to increase the comfort for the vehicle occupants at the end of a braking process by reducing the jolt to the vehicle as a result of pitching movements when the stationary state is reached.

[0003] Such a method and such a device are known from EP 0 537 874 A1. During a braking process, the braking force is adjusted down to a minimum value just before the stationary state of the vehicle is reached. The first state condition is thus met by the fact that the vehicle travels at a very low speed just before the stationary state of the vehicle. For this reason, the deceleration variable – here the braking force – is reduced. As soon as the stationary state of the vehicle has been detected, which constitutes the second state condition being met, the braking force is suddenly increased in order to keep the vehicle in the stationary state. Starting from the described prior art, the object of the present invention is to improve further the method and device for carrying out the braking process and to increase the comfort for the vehicle occupants.

[0004] This object is achieved according to the invention by means of the features of patent claim 1 and of patent claim 6.

[0005] At least one of the two state conditions depends on the front axle compression travel and/or on the rear axle compression travel. As a result the time at which the deceleration variable is reduced or increased again can be matched more precisely to the actual pitching movement of the vehicle.

[0006] Advantageous developments of the subject matter of the invention emerge from the dependent patent claims.

[0007] It is advantageous if the first state condition and/or the second state condition depend on the longitudinal velocity of the vehicle at the time of the start of the braking process. Alternatively or additionally, the first and/or second state conditions can depend on the deceleration variable. This measure ensures that the time when the deceleration variable is influenced is matched to the specific circumstances of the braking process which is occurring. As a result, a further increase in comfort is achieved.

[0008] In one advantageous embodiment, the fact that the first and/or second state conditions have been met is determined by reference to a predefined characteristic diagram. This constitutes a measure which is easy to implement in order to check the state conditions.

[0009] It is also advantageous if the reduction in the deceleration variable when the first state condition is met is carried out in such a way that the deceleration variable has a continuous profile or a profile which can be differentiated over time. This ensures the comfort of the vehicle occupants when the deceleration variable is influenced.

[0010] An exemplary embodiment of the method according to the invention and of the device according to the invention will be explained below in more detail by reference to the drawing, in which:

[0011] fig. 1 is a first diagram with an exemplary profile of the front axle compression travel and of the rear axle compression travel as a function of time, and a second diagram with the exemplary profile of the longitudinal velocity of the vehicle and the desired vehicle deceleration as a function of time, and

[0012] fig. 2 shows an exemplary embodiment of a device for carrying out a braking process as a block circuit diagram.

[0013] Fig. 2 shows a brake device 5 which is used to carry out a braking process of a vehicle (no longer illustrated). By means of a brake pedal 6, the driver of the vehicle can predefine a deceleration request which is sensed by means of a brake pedal sensor 7, and the requested deceleration variable z_{ped} is transmitted to deceleration determining means 8. The deceleration determining means 8 are used to determine a deceleration variable which describes a desired vehicle deceleration and is formed by the desired vehicle deceleration z_{soll} in the present exemplary embodiment. The desired vehicle deceleration z_{soll} is transmitted to brake actuating means 9 which actuate the wheel brake devices 10, 11, 12, 13 at the front and rear axles of the vehicle in order to set the predefined desired vehicle deceleration z_{soll}.

[0014] In the preferred exemplary embodiment according to fig. 2 of the brake device 5, further vehicle parameters and/or driving state parameters which are used to determine the desired vehicle deceleration z_{soll} are transmitted to the deceleration determining means 8. The longitudinal velocity v of the vehicle is sensed by means of a velocity sensor 18 and passed on to the deceleration determining means 8. Furthermore, according to the example a spring travel sensor array 19 with a front axle compression travel sensor 20 and a rear axle compression travel sensor 21 is provided, said spring travel sensor array 19 sensing the front axle compression travel s_{VA} and the rear axle compression travel s_{HA} and transmitting them to the deceleration determining means 8 by means of corresponding signals.

[0015] The deceleration determining means 8 determine the desired vehicle deceleration z_{soll} by means of the input signals in such a way that the jolt which can be felt by the vehicle occupants at the end of a braking process as a result of pitching movements of the vehicle is reduced or avoided. For this purpose, the deceleration variable which describes the desired vehicle deceleration z_{soll} and which according to the example is formed by the desired vehicle deceleration z_{soll} itself is reduced in absolute value according to a predefined time profile when the driving state of the vehicle during the braking process meets a first state condition.

[0016] The checking for the fact that the first state condition is met is carried out in the exemplary embodiment in the deceleration determining means 8 by means of the longitudinal velocity v, the front axle compression travel s_{VA}, the rear axle compression travel s_{HA} and the deceleration which is requested by the driver by means of the brake pedal 6. In the exemplary embodiment described here, input parameters have been used in driving trials to determine empirically which values these parameters have to adopt for the first state condition to be met. In a modification of the described exemplary embodiment it is also possible to use only the compression travel at the front axle or at the rear axle for the checking of the state condition. Further vehicle parameters or driving state parameters such as the mass of the vehicle, the wheelbase, the distribution of the axle load or the like can also be used in the determination of whether the first state condition is met.

[0017] In contrast to the described embodiment, it is also possible to use a mathematical model such as, for example, a filter or a mathematical function, for checking whether the first state condition is met, instead of the stored, empirically determined characteristic diagram.

[0018] Fig. 1 illustrates the profile of a braking process by way of example. The first diagram shows the time profile of the front axle compression travel s_{VA} and of the rear axle compression travel s_{HA}. In the second diagram below it, the time profile of the longitudinal velocity v of the vehicle and of the desired vehicle deceleration z_{soll} are shown. At a first time t_0, the front axle compression travel is $s_{va} = S_{va0}$ and the rear axle compression travel is $s_{HA} = s_{HA0}$. The vehicle is traveling at the longitudinal velocity $v = v_0$ at this first time t_0. At a second time t_1, the driver activates the brake pedal 6. The desired vehicle deceleration z_{soll} which is determined in the deceleration determining means 8 from the requested vehicle deceleration $z_{ped} = z_0$ increases steeply starting from the second time t_1, reaches the requested value $z_{ped} = z_0$ at a third time t_2 and subsequently has an approximately constant profile. The longitudinal velocity v reduces from the second time t_1 and has an approximately linear profile from the third time t_2 owing to the desired vehicle deceleration z_{soll} which has been assumed to be constant. Owing to the dynamic axle load distribution caused by the deceleration of the vehicle, the value of the front axle compression travel s_{VA} drops after the second time t_1, which corresponds to compression

travel of the front axle springs. In contrast to this, the value of the rear axle compression travel s_{HA} increases, which corresponds to spring extension of the rear axle springs. As long as an approximately constant vehicle deceleration is present during the braking process, the values of the two spring compression signals remain approximately constant.

[0019] Owing to the longitudinal velocity $v = v_0$ which is present at the start of the braking process at the second time t_1, the current desired vehicle deceleration z_{soll} which corresponds to the requested deceleration z_{ped}, the front axle compression travel s_{VA} and the rear axle compression travel s_{HA}, the fact that the first state condition is met is determined at a fourth time t_3 by reference to the stored characteristic diagram. The desired vehicle deceleration z_{soll} which is determined by the deceleration determining means 8 is reduced from this fourth time t_3 up to a predefined minimum deceleration value z_{min} according to a predefined time profile. This predefined time profile may be, for example, an e-function-like profile. Of course, any other desired time profile could also be used as a predefined time function for reducing the desired vehicle deceleration z_{soll}. It is comfortable for the vehicle occupants in this context if the desired vehicle deceleration z_{soll} at the time when the first state condition is met – at the fourth time t_3 here – has a continuous profile or a profile which can be differentiated.

[0020] The reduction in the desired vehicle deceleration z_{soll} at the fourth time t_3 causes the springs at the front axle to experience a certain amount of spring extension so that the front axle compression travel s_{VA} increases somewhat. At the same time, the springs at the rear axle experience a certain degree of spring compression, as a result of which the rear axle compression travel s_{HA} is reduced somewhat.

[0021] If the driving state during the further course of the braking process then meets the predefined second state condition, the desired vehicle deceleration z_{soll} is increased again. In the exemplary embodiment in question here, the second state condition is met when the longitudinal velocity v of the vehicle is approximately equal to zero, that is to say when the vehicle has come to a standstill. In the second diagram according to figure 1, this is the case at a fifth time t_4. The fact that this second state condition is met causes the deceleration determining means 8 to

increase the desired vehicle longitudinal deceleration z_{soll} again to the requested vehicle deceleration z_{ped}. Since this increase in the desired vehicle deceleration z_{soll} takes place after the stationary state of the vehicle has been reached, the increase can be carried out within a very short period of time without a loss of comfort for the vehicle occupants, as a result of which the time profile of the desired vehicle deceleration z_{soll} is given a very steep rising edge. When the second state condition is fulfilled – at the fifth time t_4 here – a jump function in the desired vehicle deceleration could even be predefined here by the deceleration means 8.

[0022] As is shown in fig. 1, such a time profile of the desired vehicle deceleration z_{soll} ensures that both the front axle compression travel s_{VA} and the rear axle compression travel s_{HA} have only a slight degree of overshooting in the time profile and subsequently assume their initial values again after the fifth time t_4 has been reached, that is to say after the stationary state of the vehicle has been reached. The jolt which can be felt by the vehicle occupants is significantly reduced by this, resulting in a significantly improved level of driving comfort for a braking process as far as the stationary state.

[0023] The present method and the present device can be used in particular in the field of utility vehicles since the front axle compression travel s_{VA} and/or the rear axle compression travel s_{HA} are determined in any case in said field so that there is then no need to provide an additional sensor system on the vehicle.